The Province of Alberta

IN THE MATTER OF "THE NATURAL GAS UTILITIES ACT"

—and—

IN THE MATTER OF an Enquiry into Scheme to be adopted for Gathering, Processing and Transmission of Natural Gas in Turner Valley

G. M. BLACKSTOCK, Esq., K.C., *Chairman*

Dr. E. H. BOOMER, F.C.I.C., *Commissioner*

Session:

CALGARY, Alberta March 13th, 1945.

VOLUME 9

I N D E X

VOLUME 9

13th March 1945 Page

WITNESSES

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Opening Remarks.

March 13th, 1945.
9.30 A.M.

THE CHAIRMAN: Now Gentlemen before we proceed with the cross-examination of Dr. Katz, the Board desires to deal with the motion made by Mr. Fenerty yesterday. As the Board understands the application, Mr. Fenerty asks that Royalite produce books to show the complete operations of its gas division for the years 1942 and 1943. To whom the books are to be produced and to what extent is the information thereby procured to be used is not quite clear at the moment. The reason for the request is not immediately apparent and the Board does not propose to speculate as to what these reasons may be. The application, however, does go to the question of the Board's jurisdiction to make any such order and since the Board is a statutory body, it is quite important that no order be made without the requisite statutory authority. If we make an order it is possible that one or other of the parties affected by it may want to go further with the order and for that reason we think there should be a clear cut and well defined issue, and we are therefore asking that Mr. Fenerty prepare and serve a notice of motion upon all parties who will be affected by such an order, and, in this notice he should, (1) specify clearly the precise nature of the order which he asks the Board to make, and (2) should specify his reasons why such order should be made and, (3) he should specify the statutory provisions under which he thinks the Board has jurisdiction to make the order sought.

The motion should be returnable on Monday morning

and that will be the first order of business on Monday 19th inst., and we will give our decision before Wednesday of next week.

MR. CHAMBERS: And I presume Mr. Fenerty's notice will be out in a very short time.

THE CHAIRMAN: Now there is another matter that must be clarified.

Dr. Katz, Mr. Biddison and Mr. Hamilton were appointed by the Board. The first two as engineers in their respective spheres and the third as an auditor to the Board. These appointments were confirmed by Order-in-Council. Had the Board so desired these men need not have been called as witnesses. They could have been retained by the Board as technical advisers only. Dr. Boomer and I considered that whatever advice these men might give to the Board should be known to every party interested and that their advice whatever it might be would be subjected to the test of cross-examination. Then as a matter of convenience it was decided that the evidence of these gentlemen should be led by Mr. Blanchard. The Board certainly had no idea when it made that arrangement that these men would become witnesses on behalf of the Attorney General. They are, and always have been, and still are, engineers and accountant respectively to the Board, and they are not witnesses called by the Attorney General. If there is any doubt remaining in any one's mind as to the propriety of the procedure adopted - a procedure which was purely one of expediency - then these gentlemen when going into the box will go into the box as witnesses for the Board. Their evidence will be led by the Board

and they will be available for cross-examination to every one, including Mr. Blanchard. I hope that position is now quite clear.

MR. STEER: The remark you made just a moment ago, Mr. Chairman, may have a bearing on the question which I intend to raise before proceeding with the cross-examination of Dr. Katz.

I notice that in the opening two pages, three pages, of Dr. Katz's report there are certain matters which are dealt with under the heading of "Summary and Recommendations". I take it sir and perhaps it would conduce to clearness of understanding throughout if the Board would indicate their view on this question. I take it that the documents that have been filed here have been filed as a matter of convenience and for the purpose of expediting the hearing and that except insofar as the contents of those documents are verified by oral testimony that they do not form a part of the record before the Board. I would appreciate it if the Board would indicate its view on that question.

THE CHAIRMAN: I think that the report of all these men, Mr. Steer, when they have given their evidence should be filed as Exhibits and the whole report will become part of the record and cross-examination can be directed to any part of it. If we do not do that then we will be under the necessity of having the witnesses repeat every word and quote all the figures.

MR. STEER: Now you see, Mr. Chairman, the position in which I find myself. On page 2 of this

report I read in paragraph 8: "Under the British American plan, it appears possible to pay the producer 2 cents per Mcf for all wet gas (not including gasoline value) produced at the well head within the price range for scrubbed gas of 7.75 to 9.0 cents per Mcf."

I take it sir that I am not called upon to cross-examine upon a statement of that sort and that I would not be called upon to cross-examine upon it until such time as the facts relating to that question are developed.

THE CHAIRMAN: The foundation laid and the facts will help you. That item alone cannot be accepted by any tribunal as conclusive evidence of anything stated in it.

MR. STEER: Then I propose to confine my cross-examination of Dr. Katz to the one question of the reserves in the field.

MR. BLANCHARD: I think that was covered, Mr. Chairman, by my statement yesterday that Tables 7 to 10 had no relevancy because they were simply based on estimates.

MR. STEER: Yes but I thought it advisable to have the thing clearly understood.

DR. D. L. KATZ, Cross-examination by Mr. Steer:

Q I am interested in the name that you gave to this method, The Material Balance, has it got any significance

A Yes it has.

Q What is it ?

A Well the significance is that the quantity of fluid as produced from the reservoir is one of the prime quantities used in computing the quantity that was there.

Q The quantity produced is one of the factors that is considered in determining the quantity that was originally there ?

A That is right.

Q In other words you balance what ?

A Well the pressure, the atmosphere, the nature of the gas and the quantity produced are used in a calculation that says what goes in must come out. It is equivalent to that calculation which is a general term used in the engineering profession as material balances.

Q Would you say, is there any real fundamental difference between the method which you call the material balances and the production pressure decline method ?

A The pressure decline, yes there is.

Q What is the distinction between the two ?

A The material balance is a clear cut engineering problem that has certain assumptions in it which assumptions if valid is a clear cut problem whereas the decline method of any kind I am familiar with, without making the material balance, this is an empirical extrapolation of a curve.

Q Would you suggest that there is not any question of judgment involved in the production pressure decline method ?

A Yes but the judgment is - that is right, there is judgment involved - whereas in the material balance method the judgment involved is only in the assumption and not in the calculation.

Q Now you make assumptions with regard to the original

content. Rather I should say you make assumptions with regard to the original pressure of the area. Is that right ?

A Well yes. You arrive at the figure that involves assumptions, that is right.

Q You either have given to you as a fact the original rock pressure of the area or you do assume it ?

A You arrive at it by a series of calculations including data and you finally do pick a value. I would not say exactly you assume it in the usual sense of the word.

Q Then you either have got to assume or you have got to calculate the amount of production. Is that right ?

A The amount of production was taken from the records of the Conservation Board.

Q I am not dealing particularly with this case Dr. Katz. I am trying to get a few general propositions from you. As I understand it you have either got to be given as a fact or you have got to assume that is the production of an area. Am I right in that ?

A Yes.

Q You have got to be given or got to assume as a fact the initial bottom hole pressure ?

A Well you can still calculate it whether you are given it or not. You can calculate - I would not say you must be given or assume it. You can calculate it.

Q Then you have got to either calculate, assume or be given the present day bottom hole pressure ?

A That is right.

Q Is that right ?

A That is right.

Q And the validity of the conclusions that you draw depends entirely upon the accuracy of the figures that you are given in regard to these three matters ?

A That is right.

Q Now then dealing first with the question of the past production of this field. What knowledge have you of that ?

A Well my knowledge has been primarily to the connection with the Conservation Board and their records.

Q Have you any knowledge or is there anything in the Conservation Board's records which will indicate the amount of gas that was wasted in that field, flared in the early days ?

A No I do not think-the figures are given as production. I do not think that disposition of the gas is stated, whether it was flared or what it was. I think it was stated as production.

Q When do you say that the Conservation Board first got accurate figures of production in this field and got them continuously from that time on ?

A Well I am not sure what you mean by accurate. You mean within a certain percentage of the gas ?

Q Yes I suppose. Would you agree with me that from approximately 1934 on we have fairly accurate records and prior to that time we have nothing but guesses ?

A Well I would agree with the fact that as time has gone on the accuracy has increased and early in the life the accuracy was probably very poor.

Q I would like to refer you to the 1942 report of the Board. It is in as an Exhibit I think. (Exhibit 30) Well I think you will agree with what I am telling you

that in this report of 1942 there is a statement to the effect that prior to a certain date the amount of production in this field is nothing but a guess.

DR. BOOMER: In those words.

MR. STEER: Approximately. Perhaps I had better get it. You would not agree with that ?

A Well I do not see why I should agree with it, When it is either written as it is -

Q You have not seen it ?

A I have read it but I do not happen to recall the particular figures. I am aware of the fact that there were difficulties in records in the early life of the field.

Q Well there was not anybody charged with the duty of keeping track of production prior to, we will say, the year 1932 or 1933. What would you say to that ?

A Well I have gone over history of appeals where records were kept by various individuals as they were finally compiled and the accuracy is not too good, but still it is a record that is kept.

(Go to Page 585)

Q Mr. STEER: I am reading now, Dr. Katz, from page 15 of Exhibit 28, "Early Records of Limestone Production are Little Better then guesses."

A Yes sir.

Q My recollection was much more accurate than I thought. And when would you say, Dr. Katz, that the amount of production became anything better than a guess?

A Well I don't know whether I really am sure of that. I would think along in 1931 or '32.

Q I wonder why you start your report on Page 8 - you have a copy in front of you?

A That is the July 1st report?

Q Yes. Is there any significance in the fact that you start this table with the year 1934?

A Well probably, because the records had been compiled at that time.

Q I see. Now then, what knowledge have you of the original pressure of the field?

A I have the records of the Conservation Board and the well head pressures of certain wells and the bottom hole pressures of other wells.

Q For what year?

A Well I think it is '31. I have it here if you would like me to check.

Q Yes, perhaps you would, Doctor.

A My early records are March, April and August, 1931.

Q How many wells?

A Well on this particular sheet I have got fifteen wells that I consider to be relatively early records. I have not used them all but I think I have some fifteen here in the gas area.

Q Now how accurate do you think your estimate - it is an estimate of the initial pressure of the field is it not?

A It is a calculation.

Q Yes. How accurate do you think your calculation is?

A Well I think I could show that it is not out more than 100 pounds.

Q It may vary 100 pounds either way?

A Yes, 100 out of the 2250.

Q Quite so. How do you determine your average pressure for 1944?

A For 1944, the gas cap? You are referring to the gas cap?

Q Yes?

A 1944 gas cap average was calculated by weighting the bottom hole pressures.

Q Now was the bottom hole pressure weighted in your July 1944 report?

A No.

Q No? Now tell us please how you calculated the average 1944 pressure for your July 1944 report?

A Well the 1944 reservoir pressure was not included in the 1944 report, so that I cannot answer your question in the way it was given.

Q In other words you did not require for your July 1944 report any figure as to 1944 pressure?

A No sir. I used 1943 pressure in that July 1st, 1944, report.

Q Oh, I see? And is your 1943 pressure that you used weighted pressure?

A No, it was not.

Q That was an arithmetical average?

A An arithmetical average.

Q When you came to prepare your supplementary report you decided you would weight the pressure?

A I did it both ways.

Q Did it both ways?

A That is right.

Q Now what did you use in your supplementary report for the purpose of weighting the pressure?

A I used the assigned acreage, that is, the acreage that is used in allocating the production from the well.

Q In using that assigned acreage what would be the maximum and what would be the minimum acreage that would be assigned to a well?

A As I recall probably it is 120 acres maximum and about five acres minimum.

Q What justification would you say there would be for weighting?

A In certain areas the wells are closer together, they have a large number of wells close together, and in this case if I used the arithmetical average, I have used several wells and given more weight to the area than probably should be given to that area.

Q Does that method give any weight to the area in the gas cap which is not assigned to any well at all?

A It does not in the averaging of the pressure, but it does not include the area in any sense relative to the production and with respect to the reservoir.

Q Your answer is that in weighting your 1944 pressures that no weight is given at all to that acreage in the gas cap which is not assigned to any well?

Dr. D.L.Katz.
Cross-Exam. by Mr Steer.

A No sir, I did not say that.

Q Perhaps you will tell me, I will ask you the question again: Did you in weighting your average pressures for 1944 give any weight to the area of the gas cap not assigned to a well.

A No, I did not. That is right.

Q I thought that was the question I put to you a moment ago?

A If it is I misunderstood you, sir.

Q Yes, I see. Now should you not have done so?

A If I were willing to assume that the undrilled and unassigned acreage contains the same amount of gas per acre as the drilled and assigned acreage of the field, then I should have.

Q Yes. You are not going to make that assumption?

A Well I don't think it is a method that a man should proceed with especially if a person were working on a conservative method. If a man were working on the method to find the highest answer that would be one way to do it.

Q Now, Dr. Katz, I intended to ask you a moment ago whether in the application of this material balance method of yours any knowledge of geology is required?

A Well, only a general knowledge, mostly relative to the use of pressures, and the man must have some knowledge of the field, because you cannot go out blindly and pick wells.

Q And I suppose a knowledge of geology might bear on that last question we were discussing, whether or not weight ought to be assigned to that area which is not assigned to a well?

A Well it is quite possible that a knowledge of geology would help in that matter.

Q And are you a geologist?

A I am not a geologist by profession, no sir.

Q And have you any knowledge particularly of the geology of the Turner Valley field?

A Only as I have read the general report here.

Q And I suppose you would not say that you were competent to make a judgment as to the gas content of this area not assigned to wells?

A Relative to the content of the wells, that is not assigned to the wells, no.

Q Now I am going to ask you, assuming that you have no records at all prior to 1934, you could make the computation of the content of this field?

A What is that?

Q The content, the gas content is what I am talking about now?

A Yes, you could apply the method using two successive dates, one being 1934 if you wished, and the other one any other later date.

Q That is what you said, I think, in your evidence yesterday, that you could take any two dates, you could take 1934,and 1943, or you could take any two dates, as long as I suppose they were a reasonable number of years apart?

A Wellyou could take any two dates for which you had the production in between and for which you had the pressures.

Q The evidence to which I refer to was at page 535. "It can be of course any two dates". All right. Now I suppose you will admit,Dr. Katz, that the record from 1934 on with regard to all these matters that are necessary in the application of your method are more accurate then the records prior to 1934?

A That is right.

Q Is that right?

A That is right.

Q Would it be true to say from your investigation, I wonder, that from 1934 to 1943 the records are substantially accurate?

A Yes. The recorded values, I think, I would be willing to accept them as being substantially correct.

Q Now, I wonder why you would not simply have taken a date 1934 and 1943 as the basis of your computation?

A I would be glad to explain it if you like.

Q Yes, I would be glad to have your explanation.

A The first, that is in the recent years, I feel there has been migration of gas from the oil area to the gas cap, and this migration taking place in recent years, although it is maybe not as large in percentage as the error in the early records, will influence the answer considerably more, because that being a given number has a higher percentage of the production in recent years, than a much larger number would be as an error in the production records for the total production. In addition the question of the difference between the reservoir pressure and the bottom hole pressure does not come in when I am working with the original pressure, and as a percentage basis I feel I have the average pressure at the original date closer probably than the average pressure may be computed as of 1934, even with fairly good records, and it is probably for those two reasons that I have used that.

Q The first one you gave is migration?

A Yes sir.

Q And I am bound to say that I did not follow the second one.

A In computing the pressure in the reservoir as of a given date during the production stages 1934, 1936, or 1943, and taking 1934, 1936, there is a question as to whether the bottom hole pressures represent the reservoir pressure. And by various weighting methods one can arrive at the reservoir pressure that is considerably different from a different method. It even might be as much as 60 or even 100 pounds out of a total of 1500. So that is a larger percentage of the reservoir pressure at that time then I believe the error is that I had in the initial dates when there is no question as to the reservoir pressure as compared with the value that could be measured now as well.

(Go to page 593).

Q Well, I would suggest to you, Dr. Katz, that you might better have taken your accurate data, make your computations and then follow back with respect to these two matters you have just spoken of, rather than relying on what has been stated to be nothing but guessing.

A Well I believe that the initial pressure, and using the production records from the beginning, was fully as logical a procedure as any other.

Q I see. In any event you have not made a computation of the production of this field based on the 1934 to 1943 records?

A Well I have studied that. I have one computation I made in that order.

Q Now I do not know whether I can follow this through with you or not, Dr. Katz, but I would like to attempt it. If you will turn to page 8 of your report. Now your No. 1 on that page, as I see it, or rather I am interested in that, shows that from the 31st of December, 1934 to the 31st of December, 1943, there was a production from the gas cap of 399.8 billion cubic feet, would that be right?

A That is right.

Q Yes. Well then, reading from No. 4, I take it that the reservoir pressure in 1943, December 31st, was 536 pounds.

A That is right.

Q And your No. 5 shows that there was a compressibility factor on that same date, 31st December, 1943, of .903.

A That is right.

Q So that from those items you get a conclusion in No. 6, that as at the 31st of December, 1943 under the assumed pressure and temperature, 1 cu. ft. of your pore space would contain 39.4 cubic feet of gas.

A That is right.

Q Well then, from No. 7 we gather that the number of standard cubic feet of gas given up from the 31st of December, 1934 to the 31st of December, 1943 was your 73.1 in No. 6 for 1934, less 39.4 for 1943 or 33.7 cubic feet, is that right?

A That is right.

Q Well then, will you compute for me the number of cubic feet of pore space from which our original 399.8 billion cubic feet of gas must have been produced, I suggest to you that it is about 11.9 billion.

A 11.9?

Q Yes.

A Not 11.9, it is 1190, is that not right, 1190.

Q 1190 billion?

A The original content computed, is that right.

Q The way I have it computed here is, to account for the 399.8 billion cubic feet of gas that must have been produced from . . . . .

A 11.9 billion cubic feet of reservoir space.

Q That is right?

A That is right.

Q 11.9 billion cubic feet of reservoir space?

A Yes.

Q Now the reserves of December 31st, 1934 can be calculated by multiplying 11.9 billion cubic feet of pore space by 73.1.

A That is using the data as of 1934.

Q 1934, yes. Now that calculation to me is 870 billion cubic feet.

A All right.

Q Is that correct?

A That is right.

Q Now then if from that 870 billion cubic feet of 1934 we deduct 399.8 billion for the 1934 figure, we get 470.2 billion cubic feet of gas, produced in the interval, is that right?

A That is right.

Q Now that is down to a pressure of . . . . .

A That is total pressure atmospheric, I mean down to zero pressure.

Q Yes. Now your comparable figure for that 470.2 billion is what?

A Would be 273.

Q Yes. Then what you did in 11 and 12 is to get the figures down to 250 pounds and 100 pounds abandonment.

A That is right.

Q I am told that if I get my 470.2 billion down to 250 pounds it would give me a result of 255.2, would that be right?

A Well I assume that it would be, I would have to calculate it but it sounds right.

Q It sounds all right?

A Yes.

Q And if we calculated down to 100 pounds we get 380.2, does that sound all right?

A That sounds all right.

Q And those figures would compare with your 149 and 221?

A Yes.

Q Now before I leave this question of the gas cap, I would like to call your attention to this supplementary report of yours on page 1, the recalculations for your July, 1944

report and your 1945 supplementary report were made nine months apart?

A That is right.

Q And there seems to be some fairly wide discrepancies, Dr. Katz, - I do not know whether they are wider than your method might expect or not, - perhaps you will tell us how it comes that within nine months you estimate the gas cap as 31.7 and then 28.6.

A Well that is the result of the calculations of the data, I mean that is about a 10 per cent difference.

Q Yes. Well then, there is a difference in the crude oil gas in the Madison or major field of 112 as compared with 140, that is a pretty substantial difference.

A Yes, there is about 20 per cent, that is right.

Q Yes, and there are differences from, we will say, varying from 5 per cent to 20 per cent in your calculations nine months apart?

A That is right.

Q And how would you explain those?

A Well the primary differences are due to the results of the gas production and the change in pressures which have taken place a year apart, in most cases because the datas were taken a year apart while calculations were made nine months apart and slight changes were made by making independent calculations and slight modifications in the method.

Q Then do I take it that if you make another estimate a year from now that, on your method, we can expect variations either way of from 5 to 20 per cent?

A Well I would say it is quite possible that you would, and the direction though is more likely to be up than

down.

Q I am told that the variation in the Madison for the remainder of the field is between 112 and 140, is 25 per cent rather than 20.

A That probably is right.

Q So that we can just raise our possibility of error to 25 per cent.

A Yes, that is relative to the gas being produced from the field and of course not dry gas, wet gas.

Q Yes. Now coming to the oil, you take certain bottom hole pressures in your July, 1944 report, quite substantial, 2720 for the B.A. area and 2700 for the G.O.P. area and 2865 for the North area, you recall those pressures?

A The origianl pressures you are speaking of?

Q I do not know.

A Is that right?

Q They represent the original pressures, yes, and then as I understand it when you are computing the amount of gas which is to be got from the oil wells of the field, you suggest, you assume that the gas is withdrawn to a bottom hole pressure of 250 pounds?

A That the gas is withdrawn down to an average reservoir pressure of 250 pounds, that is right.

Q How do you arrive at the 250 pounds?

A That is arrived at by a knowledge of the tightness of the formation and the expected final pressure which one is going to have in the field.

Q Is it your suggestion that the wells will flow at a pressure of 250 pounds?

A No, I do not say that.

Q You do not say that?

A No.

Q If they are not going to flow how is the gas going to be got out?

A The gas can be produced from some of the high gas/oil ratio wells of the gas cap, possibly from gas wells.

Q In other words, what you suggest is that these wells will be closed in as oil wells, they are not going to flow oil anyway, are they?

A I think it is possible for them to flow but I do not think they necessarily all will. I have flowed an oil well.

Q . . . . . Just a moment, do you suggest, do you suggest that one of these wells will flow oil at 250 pounds bottom hole pressure?

A Well I have flowed a well 6500 feet deep at 265 bottom hole pressure.

Q In Turner Valley?

A No.

Q What you suggest then is when they cease to flow that they are going to be closed in and the gas that would otherwise be produced from that well is going to high-grade into the gas cap and be produced from the gas cap, is that your suggestion?

A No, I do not know, necessarily the reports which have been given of other flows and the way it has been presented is that most of the wells are going to be high gas/oil ratio wells and I do not necessarily set down a detailed plan by which the reservoir is to be operated but I set a figure of 250 pounds, being the likely figure to which the reservoir would go.

Q Now, Dr. Katz, if these wells will not flow oil at any

pressure below 600 pounds, your calculations as to the amount of gas in the oil area are seriously in error.

A I would say that if the reservoir pressure at abandonment is 600 pounds, yes, that that is true.

Q Would you be surprised to know that the Coronation well producing 30 barrels of oil a day is operating at pressure of 790 pounds?

A Not particularly, no.

Q You would not be surprised at that?

A No.

Q Would you be surprised to know that the Prairie well, producing 25 barrels of oil a day, is operating at 725 pounds?

A No.

Q Would you be surprised to know that Spy Hill, producing only 12 barrels of oil a day, is operating at 635 pounds?

A No.

(Go to page 600.)

Q Would you be surprised to know that wells in the vicinity of the gas cap producing around ten barrels a day are operating at 600 pounds ?

A No, I of course know that.

Q Have you any idea as to what the bottom hole pressure is which would lead to abandonment of one of these wells as an oil well ?

A I do not know.it is necessarily related to the bottom hole pressure. I think it is related to the oil production.

Q Does the oil production depend upon the bottom hole pressure ?

A Only in part.

Q What else does it depend upon ?

A It depends upon in the first place upon the Brown allowable and in the second place upon the gas oil ratio.

Q Am I wrong in thinking it is gas pressure on the oil in the bottom of the hole that drives the oil up to the surface ?

A Yes.

Q I am wrong ?

A No, you are correct. The gas pressure brings the oil up to the surface but you have an excess of pressure to bring the oil up if you have the ideal conditions.

Q Well now if evidence is produced here to the effect that these oil wells will not be economically oil wells at under 600 pounds pressure then your calculations as I think you stated a moment ago are seriously in error as to the amount of gas to be produced from the oil area.

A If by your statement you assume that the oil area will not be produced below the reservoir pressure of 600 pounds you are right.

Q Now I think there is one other point, perhaps that I have got to cover with you. Your report on Page 24. Now we are dealing with the quantity of gas that is going to be saved by this scheme under consideration and as I understand what you have here on Page 24 you say:

"That in the year 1941, 16.2% of the field production was sold." Page 24.

A Page 25, I am sorry.

Q Am I right in that ?

A Yes, that is Table 7.

Q That percentage is the percentage that is supplied to the next column to the left, is it ?

A It is the percentage of the wet field gas produced which the column to the left represents.

Q What I would like to ask you is whether your 16.2% is applied to wet gas or dry gas ?

A 16.2% represents the percentage of the wet gas which was sold as dry gas.

Q I see, and then it rises in 1942 to 20.8 and in 1943 to 33.9 and it rises in the first four months of 1944 to 41.8, a continual upward trend ?

A That is right.

Q But in your computation of the amount of gas that is saved you stop right there don't you ?

A Yes, it is because the statement says, at the present degree of conservation. It is very specific in stating that. That is right.

Q At the present degree of conservation ?

A That is right.

Q Well there was not any degree of conservation in force all through this period was there ?

A I could have said at the degree of conservation which took place in 1942 and used the 20.8 for example.

Q Your figure of 41.8 as I understand it is the figure that shows the amount of gas that is sold under conservation as applied prior to the coming into force of the scheme that we are considering ?

A Yes just prior to that, that is right.

Q Now then there was no other conservation scheme in force prior to the first four months of 1944 was there ?

A Well I would not say there was. I do not think there was. No,I will say there was a gradual -

Q Let us assume there was not and from 1941 to 1944, the first four months, we have got a continual rising trend of the percentage of gas sold, have we ?

A Yes sir.

Q What assurance have you got that that trend would not have continued all through 1944 and in 1945 and so on ?

A Well I think I stated that it is likely to have gone up under normal circumstances.

Q And might amount to 60% ?

A Well near the life of the field I believe most fields increase their degree of conservation with time .

Q There has been filed here, Dr. Katz, the December 1944 report of the Board. Page 6, Exhibit 30. It is down a little less than half way down the page. There is disposition from Turner Valley. Do you follow that ?

Dr. D. L. Katz
Cross-Exam. by Mr. Steer.

A Disposition from Turner Valley, yes.

Q In the year 1944, that is the second column, the report says a total of 41,377,528 Mcf. produced from Turner Valley. Is that right ?

A That is right.

Q Waste is shown as 14,730,645 Mcf ?

A That is right.

Q A percentage of 35.6. It follows from that does it that 64.4% of the gas in Turner Valley in 1944 was usefully employed ?

A Usefully employed but not sold to market necessarily.

Q Quite so.

A Yes.

Q And I suppose that as we go on the same quantities of gas that are used for the Imperial Refinery and town of Bow Island and field fuel and plant shrinkage will have to be considered ?

A That is right.

Q And so that wastage amounts in 1934 to 35.6% of the total production. Is that right.

A That is what the figures state, yes.

Q And you did not intend by the use of your 41.8% to indicate that 58.2% was wasted.

A No sir I did not mean to imply that at all.

Q Now on Page 588 of your evidence, Dr. Katz, as I understand you make the suggestion that the gas will migrate up structure as I understand it. I notice in your report you talk about the gas migrating down structure from the gas cap into the oil, migrating

down structure from the oil area to the gas cap. Did you mean that or is it a mistake ?

A If it is there it is a mistake, because it goes up structure from the oil zone to the gas cap. What page is that on ?

Q I think I have it for you. "It is known that the gas cap has enlarged and that migration of gas from the crude oil areas down structure into the gas area has taken place."

A The crude oil areas down structure, that is what I meant.The migration is not down structure.

Q Oh, down structure applies to the crude oil areas ?

A Yes.

Q It is a sort of magic expression ?

A Yes.

Q But there is not any difference between us if I say to you that the gas from the oil area has to go up structure in order to migrate to the gas cap ?

A No, we agree.

Q That is right ?

A That is right.

Q Then I think you stated at Page 558 that there is going to come a time perhaps when that direction is going to be reversed ?

A Yes sir.

Q The direction of migration is going to be reversed ?

A Yes.

Q Would you tell us within what length of time that will take place ?

A Well a person could sit down and make calculations that would help him better than to make an estimate but I

assume it is a matter of five to seven years, something like that. It is when the pressure in the gas cap exceeds that in the oil area. Of course the migration will go from areas of high pressure to areas of low pressure.

Q Have you ever known a case where the reverse of the trend had occurred ?

A I do not happen to recall any at the moment.

Q Well now for the five years or more during which migration is going to take place from the oil field up to the gas cap, gas which normally might be produced through oil wells is going to be produced through the gas cap ?

A That is quite possible.

Q And whether that reverse in trend takes place is something for the future to take care of ?

A That is right.

Q Thanks.

CROSS-EXAMINED BY MR. FENERTY

Q Dr. Katz, in your material balance method of calculation where you tell us that the volume in the gas cap reservoir will remain for all practical purposes constant, would water migration or intrusion in a well, say in the B. A. oil area, have any effect in the calculation ?

A If water that came into the reservoir in the down structure wells displaced the reservoir oil and gas that was originally there, it will have bolstered the pressure to that extent and if my pressures are high I compute reserves which are too high.

Dr. D. L. Katz,
Cross-Exam. by Mr. Fenerty.

Q Now turning to a question which is perhaps one of engineering rather than geology which I understand is your work, I find in one of the reports filed, Mr. Mercer's not yet proved, the statement,

> "The economic feasibility of the place of repressuring and conservation so far as Royalite is concerned rests upon the opinions of the engineers of Royalite that repressured and conserved gas will not migrate from the gas cap to any great extent."

. Now I gather from what you told us yesterday and which is found at Page 558, and on the material balance theory that it is not necessarily so.

A The migration is not necessarily so.

Q No, that there will be no migration. It does not agree with your theory ?

A I think there will be some migration.

(Go to Page 607)

Q And I refer to the report or the theory of the engineer of the Royalite that there will be no migration. Now you have also told us that there my be considerable addition to the reservoir volume of the gas cap from the oil area depending upon the relative pressures in the area.

A Yes, it is quite possible that gas will migrate from the oil area into the gas cap and will be produced there, that is right.

Q So that the gas cap, on the basis of the re-pressuring system, the gas cap will receive a large volume resulting from the re-pressuring of the dry gas.

A Yes.

Q And as the pressure in the oil area decreases you would expect migration of the gas then into the oil area?

A If the pressure in the oil area becomes less through production, then you would expect migration and a probable or possible result of that will be that some oil wells will become gas wells.

Q And as you say "the extent that that takes place, part of the reserves that might have been in the gas cap might actually have been produced through oil wells eventually."

A That is right.

Q And I suggest to you that that cycle will be repeated and that gas will again form a part of the gas lift in those wells. I mean the gas that has migrated will be used as a gas lift.

A Yes, that is right.

Q And to that extent will benefit the oil production of those wells.

A Yes, and of course it also will go to the benefit of

the gas operator.

Q But there would be some benefit to the oil well?

A Yes.

Q In the way of increased oil production?

A Yes.

Q And also that gas will then be put through the absorption plant and will be ready for marketing by the same people?

A Yes.

Q And we have this result, you have the original gas lift for the oil production and on account of the lower bottom hole pressure and the migration of gas, you will get a second lift and you will get a third gas lift, is that right?

A I think there when you are speaking like that you are assuming that there is an unending migration and a constant production of gas and that is wrong, or I do not necessarily agree that it will be of that magnitude.

Q I am not going to suggest how long or how short it may be until you get to the place that it diminishes to such an extent that it cannot be used but you may get eight or ten lifts and that will continue as long as the migration takes place and the result of that will be that the oil well will benefit from the production of oil.

A If your point is . . . . I do not understand your question clearly, would you repeat it?

Q I say to you that the result of that progressive situation whereby you have a diminishing benefit each time you have a gas lift in this cycle, not just at once but perhaps some years from now, we will get to the position where the final gas that is brought out of that will be maybe

needed for some other purposes or it goes into the gas cap and is used for those purposes and you will find then that all the gas production of that well has been used in the oil industry for producing oil.

A And the gas that is used in the industry for the production of oil is available for use, you use it. It comes to the well head and it is used. It goes through the absorption plant.

Q And from the absorption plant it is carried down as dry gas downstream in a diminishing volume and whether you have 4 or 8 times it is valuable to the oil company, is it not?

A I think that the total gas production from the oil business cannot be said to be doubled or trebled or anything of that order because the migration would certainly not be to that extent.

Q You understand that I am not arguing with you. I am just agreeing with you and I am trying to bring out what the situation is. I think we will leave that for the moment. Now Doctor, you did refer to the estimated annual consumption of 12 billion feet of gas.

A Yes.

Q And that of course necessarily is an estimate. Everybody estimates.

A Yes.

Q I think I am right, am I not, in saying that that is more than some estimates you have seen and it is considerably in excess of other estimates. Not perhaps for this year or next year but for the succeed-

ing years. That is right is it not?

A Yes, I believe it is.

Q And if it should turn out that these lower estimates are correct that would necessarily throw out your calculation as to cost and the situation generally would it not?

A Yes. Of course if the calculations relative to costs here are thrown out, there are other considerations as well.

Q There are several other things that I might mention now and I will not have to come back to them. If, as I understand it, you had found a situation where you have a lower consumption of waste gas for heating and industrial purposes than estimated you will in turn, perhaps, have a longer life for the field and you will necessarily have greatly increased costs per thousand feet of gas to anybody using it, if it is to be paid for. Would you go that far with me?

A I am not quite sure I understand your question.

Q What I am trying to get at is this, and perhaps I am straying into the field of economics and perhaps if so I will let it go. In this plan of conservation we have we are going to have interest charges on capital investment by somebody. Somebody is going to have them. I am speaking of everybody here when I say we and not the clients I represent. We will have interest charges and wages charges which to some extent may remain constant. Not constant, but will remain at the same figures as they would remain whether you have a 12 billion consumption or a 9 billion consumption would it not?

A Yes, I think that generally . . . . .

Q If you are going to meet these particular charges out of a 9 billion consumption they have to be higher per thousand feet than if you met them out of a 12 billion consumption, that is just arithmetic is it not?

A Yes, I guess that is the result.

Q Let us leave that for the moment and come to these next things. So far as the natural gas industry is concerned, divorcing it from the oil industry I suggest to you there is no problem of storage and no problem of production in the Turner Valley field, treating it as a gas industry alone, is that right?

A Well are you referring to prior to this time?

Q What I am getting at is this, that the cheapest place to store gas is in the ground.

A Well . . . . .

Q That is right, is it not, rather than in tanks?

A Yes, I think so.

Q And the problem that is confronting us today is the problem involved in what is referred to in the Conservation report as waste gas. You remember it was called waste gas in the report?

A That is waste gas coming from the gas cap in the South end of the field, the oil area..

Q I mean that waste gas of 20 billion feet in 1943 and that is not an incident of the gas industry is it?

A Well a portion of it comes from what you call the gas industry because of the operation of the migration from the gas wells in the South end of the field.

Q It was not necessary to waste that gas in order to supply furnaces in the city of Calgary?

A No, not to waste.

Q MR. FENERTY: Dr. Katz, that wastage is the result of oil production in turn resulting from the production of gas from the well, is it not?

A Well partially. Part of it is from gas wells that were not putting their gas to a useful market.

Q And partly from gas wells which are producing natural gasoline through absorption plants.

A That is right.

Q What I am getting at here is that the only reason you have a waste problem is that we are producing oil and natural gasoline in the Turner Valley field, is that right?

A Well the only reason you have a waste problem is you have all the wells producing and the total quantity of gas produced is more than the available market.

Q In other words, what I am getting at is, waste gas is an incident of the production of oil and gasoline in Turner Valley field, and an incident of that alone, am I right?

A Yes, I guess that is right.

Q Yes, I think it is obvious. And I note from the figures here, from your figures, Dr. Katz, - pardon me just a moment. Now I am looking at page 24, page 24 of your report, Doctor, and I find for instance in 1943 wet field gas produced 44 million odd, gas sold 14 million odd, and I gather from that, 33% of the production was sold, and I gather from that that the quantity of gas used by the absorption plant gasoline industry is roughly three times that used for fuel purposes and industrial purposes. That is just arithmetic.

A No, the statement I think, if you made it, is that the quantity of - the correct statement I would say that parallels yours is that the quantity of gas sold is 33% of the total production.

Q Yes. But you use 44 million feet of gas in the absorption plant industry. It may be it is used again in something else but you use it. And if there were no markets for fuel purposes and no conservation, it would be completely used in the sense it would be blown off in the air?

A It would either be used as fuel in the field or blown in the air.

Q And I say it is used in the absorption plant industry. Now somebody else might have another user, but for the moment the absorption plant industry used in 1943 44 million feet of wet gas, didn't it?

A I don't know that it all went to the absorption plant. It was produced from both oil and gas wells. I don't know whether it necessarily means that it was all used there.

Q Well we will say there was a production there?

A Yes, that is right.

Q Which was produced as an incident of the oil and gas industry?

A That is right.

Q Now let us assume for the moment that for some reason, whether in conservation of gas to prevent waste or for another reason, you have no Alberta Nitrogen plant and you have no users of gas in the coal furnaces and the gas heaters and so on. I suggest to you then that in order for the oil industry to continue to operate, or the natural

gas, there must be necessarily an increase in the wastage. You see, over and above, take '43, 1943, 44 million feet of gas you have got 14 million that was not wasted. There must necessarily be an increase in the wastage and a very much greater expense to the oil industry conducting its operations. That follows does it not?

A Yes, that is as I understand your question in '43?

Q I used that.

A That the gas sold would have been lost.

Q If you had no gas sold?

A If you had no gas sold.

Q Then you have got to blow that 44 million feet in the air....

A 14.....

Q Or rather the results of it after the wet gas taken off?

A Yes.

Q You have to blow it off into the air, or you have to re-pressure the whole thing, and your individual well owner cannot re-pressure in his own well without destroying his well?

A Yes.

Q So that he has to re-pressure through the gas system?

A Yes, if he wishes to re-pressure the gas.

Q Then I suggest to you that it follows that if the gas is not going to be flared or wasted, as the Board reports put it, that the only way that the oil industry can produce oil without greatly increased costs, is to have a very substantial market for the by-products, dry gas, downstream from the absorption plant. Does that not follow from what I have said? Let us go back for the moment

Perhaps I have jumped too many hurdles.

A It makes a lot of difference whether you are talking before conservation or talking after.

Q Perhaps I am jumping too many hurdles. Let us take 1943. We have 44 million gas produced although in 1943 there had been 14 million sales of dry gas, then you would have 44 million feet of gas, dry gas, downstream from the absorption plant to deal with.

A Or from the oil wells, whichever it was produced from.

Q Yes, to deal with. And you would have to do one or two things with it, as far as you know, or, if anything else, you tell me, you would have to waste it, the whole 44 million or you would have to re-pressure.

A Well a portion of it is used in the field's operations.

Q Pardon me, of course I understand that. But leaving out certain usages in the field, taking my figures in the main they would be relatively correct. You have your 14 million feet to deal with but you would be able to get rid of it by burning it in furnaces and in industry?

A Yes.

Q You would have 44 million to deal with, you would have 14 illion more, that is what you said, in that year, if you didn't have consumers and industry and so on. You would have much more wastage but you would have increased repressuring operations, wouldn't you?

A Yes, because the portion of that 44 million was actually produced in the gas cap for market. It might not have been produced, a portion of that, you see, would not have been in the market.

Q All right, but they are oil wells. Let us take it this way.

Cross-Exam. by Mr.Fenerty.

The gas cap production goes to the absorption plant, if it were not for this conservation?

A Yes.

Q And the oil well production results in greater production. So that when I refer to oil wells it does not make any difference in my consideration whether he has gas or oil wells. So that from the entire field that you used for the 14 million consumption in '43, you would have 14 million more gas wasted?

A Well if you would have produced 44, you are assuming 44. You are assuming that if there had been no market.

Q Yes. And if they did not produce it they would not have the production of oil and gasoline that they did have.

A That is right.

Q So that if the oil and gasoline industry maintains its production, I say, their costs are going to be greatly increased or there is going to be a great deal more wastage of natural gas if the sale of gas for heating and commercial purposes disappears. That is obvious, is it not?

A Yes, it is.

Q Well I suggest to you that this follows that - let us go back to where I started. With increased price of gas to the consumer the consumption tends to drop off, that is just elementary, is it not?

A Yes.

Q And when you come to the commercial end, the underfed stoker and the pea coal and so on, the convenience there is not like it is to the householder. It is cost that counts with them. And you will agree with me that if the annual consumption drops off the cost per thousand feet

will rise. You see we have our interest charges, you will remember, and our wages.

A Yes, although not proportionately necessarily, but they will rise.

Q If they rise again the consumption drops off doesn't it? That is just elementary?

A Yes.

Q And you have a complete circle whereby you get to a point where this 14 million feet used disappears sometime. They don't just pay for it, that follows?

A Yes.

MR.BLANCHARD: If the price is high enough?

A But for example, I may 80 cents for gas in Ann Arbor in my home.

Q MR. FENERTY: Dr. Katz, what I am leading up to, which I referred to before, and ask you now, that it is absolutely essential to the oil industry in order to continue to operate under a conservation plan to have dry gas available at a price which will at least maintain the production market or perhaps increase it; does it not follow that that is so?

MR BLANCHARD: I suppose that is a matter of argument.

MR. FENERTY: I thought it is but I thought some defects might develop when Dr.Katz was here.

Q DR.BOOMER: Dr. Katz, do you know of any area or gasoline field that operates without market for the gas and does not waste it?

A That operates without a market for the gas and doesn't waste it?

Q Yes?

Dr. D.L.Katz.
Cross-Exam.by Mr.Fenerty.

A No. I know of no operations.

Q How about up in your field?

A They put the gas back in the reservoir.

Q Do they use only the amount of gas needed?

A Yes, and the remainder goes back into the ground entirely.

Q MR. FENERTY: Dr. Katz, just one more question. Doctor, you referred in evidence and in your report, page 9 of your report, this wasn't read, but you did refer to economical production, and you said there that the installation of field compressors and so on does not appear to be economical. Now just what is your yardstick as to what economical production?

A Probably my yardstick in this city for economical production is whether you would have to raise the price of gas a matter of two or three or four cents over the present price.

Q And on this theory developed a while ago I would gather that it would not be economical. Are you basing it on present prices of gas when you say not economical?

A Well yes, because you have to take into consideration the present price of the gas where you are at. You would have to take it on what the price is here. It might be economical somewhere else.

Q Would it be fair to say this, that it would not be economical to do this and that you are basing that on the present price of gas.

A Yes, the present price of gas and the locality where you are. The present price of gas here.

Q And we are pretty well agreed that it would not be economical to increasse the price if it results in a lesser consumption of waste gas.

A Yes, if you are thinking of doubling or trebling the price then I agree with you. If you are thinking of a nominal increase I am not so sure.

Q So that it follows from the general remarks you have given and the observations of the field that we must necessarily consider the present price of gas and then see how it can be allocated. That is the net result of the whole thing is it not?

(Go to Page 620)

MR. BLANCHARD: You mean the present price at the intake of the Gas Company's main.

MR. FENERTY: The present price, that is a necessary result of that.

THE CHAIRMAN: I suppose, Mr. Fenerty, what the Board must do to carry out the directions given by the Statute is to find the just and reasonable price according to the facts presented to it and then the people of Calgary will decide whether they want to buy gas or not buy gas.

MR. FENERTY: I will not pursue it further but there was a reference to prices and two cents at the well and so on and I was just carrying out the logic of those discussions, which we have had, to its conclusion.

THE CHAIRMAN: I do not want to hurry you, Mr. Fenerty, take all the time you want.

MR. FENERTY: No, that is the end of it.

THE CHAIRMAN: Then we will adjourn for ten minutes.

(A short adjournment was here taken).

THE CHAIRMAN: Mr. McDonald?

Cross Examination by Mr. McDonald.

Q Dr. Katz, yesterday I understood from you that your estimate of the reserves was conservative?

A That is right.

Q And that if there was any error at all the error was on the conservative side?

A I feel that the figures I have, you might say, are certain and if there are errors they are likely to be on the low side, that there would be more gas there than I gave.

Q And in spite of the discrepancies as we will say of certain phases of the calculations made, that arises out of using your material balance method, and still they are conservative?

A That is right.

Q I think you mentioned twenty percent yesterday would be a fair range of error?

A That is right.

Q I take it if I recollect your figure was three hundred and fifteen billion cubic feet of dry gas available for market?

A Three hundred and seventeen is the figure in the supplementary report.

Q If that was increased by twenty percent it would be somewhere in the neighbourhood of three hundred and sixty billion or three hundred and seventy billion?

A That is right.

Q So that allowing ten percent or fifteen percent error, still it would be very close to some of the other estimates which your summary shows are three hundred and fifty-three, three hundred and fifty-five --?

A That is right, it just brings the results of the most of the crude, residual gas --.

Q Very close together?

A Very close together.

A Very close together.

Q And also in your estimate you use straight percentages for deductions from wet gas?

A That is right.

Q Fifteen percent in the gas cap production and thirty percent in the --?

A In the oil area.

Q In the oil area. The others use twenty-six percent and eighteen percent in their respective calculations, twenty-six percent in the crude?

A Well I, my answer to that is I believe they use different percentages in different areas and they are within the same range of over-all but there have been different percentages for different areas used in the different methods. Possibly my thirty percent is more accurate in that it includes in gathered gas and many of the others necessarily did not include that in the percentage in converting wet gas to dry gas.

Q Now what is the producing horizon of Turner Valley, what is the age and type of the horizon?

A Well I understand it is Mississippian Lime?

Q Is that limestone?

A I think so but now you are examining me on geology and I am not necessarily a geologist.

Q Is it permeable?

A As a general classification it is not very permeable. It is a relatively tight limestone. In most cases it would be so considered. In other words the drop in bottom hole pressure is much higher in Turner Valley than in most fields with which I am familiar.

Q So that you would expect a larger volume of gas in Turner Valley than you would in a permeable field?

A No, the movement in a non-permeable field would be low but in

a permeable field it moves very rapidly so that it does not mean there would be no movement if the permeability was low but it would be much lower than if it was a very permeable field.

Q What I am interested in is, the field has been in production since 1928 or 1926, and there has been gas produced in Turner Valley since then?

A Yes.

Q And your explanation of it is that there is more or less of a uniform resevoir over all the field?

A Yes, uniform, but still with many non-uniformities.

Q But generally?

A Generally speaking, yes.

Q And in some areas gas will move more than in others?

A Yes. One of the things that I think I should say and which will help to clarify what you are discussing is that the ability of gas to move in a gas horizon where you have a single gas phase, is much greater than it is for gas to move in an oil horizon where you have the liquid phase.

Q So that for gas to move from the crude oil area to the gas cap area --?

A In order for that to happen it would be necessary I feel for it to happen to a considerable degree, or to increase its rate of happening, it is necessary that the percent of the gas phase that occurrs in the rock increases a certain value, there are figures on that, studies have been made of course on the ability of gas to move from rock depending upon the percentage of that rock which is filled with the gas phase, and I would say it is something in the order of thirty-five percent, twenty-five to thirty-five percent of the space in the rock must become a gas phase before you will have substantial gas migration. It is a known fact and

has been studied in the laboratory and it is fairly well understood.

Q That is what you refer to in your report on page 4;

"Migration of gas from the oil area appears to depend to a large measure upon the oil area developing a given saturation of gas phase which results in the high gas-oil ratio wells. The migration of gas will continue in the future and a portion of the gas initially with the crude oil will appear as gas cap reserve."

A That is right. I was explaining that statement.

Q And where does that occurr in Turner Valley?

A Well before the oil area was drilled the oil, the rock in that area presumably was filled with a liquid phase and although the pressure retained would differentiate between that area and the gas cap, the tendency of the rate for the gas to travel or the fluid to travel, is really would be, from the oil area to the gas area was very low until such a time as the oil area was produced to create locally within the oil area a certain percentage of gas phase within that oil area itself and as that developed the gas moved more freely.

Q What type of differential would there have to be to have gas move?

A Well of course in general it moves proportionately to the gas-gil ratio.

Q What evidence have you of that in Turner Valley?

A Well the gas cap area has always been at a lower pressure than the oil area since the records have been kept.

Q That is true, the records show that?

A Yes.

Q But how much gas has moved in Turner Valley into the gas cap?

A Well I do not know that anyone has ever computed it and it would only be an estimate. I know of no way of getting an exact computation of it.

Q Is there any way of ascertaining what part of the gas cap it would go to, from what crude oil field and area and so on where it would go?

A Oh I believe the best that could be done would be to arrive at, by consideration of some percentage of the total gas, I know of no way of computing the cubic foot or anything of that kind.

Q Has there been any, - what I have in mind is this, in the early days in the gas cap in the Turner Valley, say in 1936, there were gas cap wells drilled in the south end which have been producing for some years and had a lot of bottom hole pressure?

A At the time they were drilled.

Q No, at the time they were abandoned and discontinued or shut in; Now since that time an oil field has been discovered in the south end and I have been given a bottom-hole pressure of twenty-two hundred and fifty?

A That is the original.

Q The original?

A That does not necessarily mean at the time the oil wells were drilled but at the time the oil reservoir was discovered.

Q Now, a great many wells came in down there --?

A That is right

Q Now since that time the gas in this crude oil area has to some extent changed into a gas space, has it not?

A A portion of it, a portion of it has been produced, that is right.

Q And there has been no corresponding increase in the pressures in the gas cap in that area?

A There has been an increasing, - I think it might be said, an increasing quantity produced per pound reservoir pressure drop or, if you take the figures as of 1936 and compute the original reservoir pressure from the original date and then compute it as of 1938 or of 1943, one can see that the reservoir pressures have been off and one can also see that that rise in quantity of gas, which appears to have been there originally, came partially from migration. We have no way of knowing which of the two factors caused it to be taken that way.

Q Have you any idea of the percentage that that would occur, if you say that occurs. How much -- you do not know?

A I do not know. It would be purely a guess if I gave a quantity. It would be an off-hand guess of what I thought.

Q Yes. Now I think your tables show, I will pick one out on the south end, in 1943 I thik you gave these figures, there was a bottom-hole-pressure of eight hundred and eighty-nine in the B.A.area, page 15?

A Eight Hundred and eighty-nine, yes.

Q And the gas cap area, take item two on page 11, five hundred and seventy?

A For the 1943.

Q Yes, oh yes, five hundred and seventy, there was a differential there of how many pounds?

A Three hundred and ninteen.

Q Have you any idea of the percentage of gas that was travelling from the crude reserves to the gas cap reserves in that percentage?

A No, I have not given consideration to arriving at a figure. One thing you would have to observe is that that three hundred pounds exists for a fairely long distance, there is not that differential between a short distance.

Q It might be less than that in a short distance?

A It might migrate from part of the oil zone to another part of the oil zone as well as reaching the gas cap itself.

Q I am interested in the migration from the oil area to the gas cap?

A If you take the pressure in the oil zone, which you would call the edge of the oil zone and take its pressure relative to the pressure in the gas cap, it might not be the full three hundred and ninteen pounds.

Q It might only be one hundred pounds?

A It might only be one hundred pounds.

Q Or it might be less?

A Yes, that is right.

Q There would be a very large oil migration under those circumstances?

A I do not believe there is any way of knowing whether there is, at present I know of no way of arriving at it but I do not believe it could be said to be negligable nor do I believe it could be said to be extremely large.

Q We are speaking now of static conditions. I am speaking of the pressure in the crude oil area remaining at five-seventy and eight hundred and eighty-nine in the gas cap but in actual practice that does not occur, both reserves are going to be depleted under the present plan of the British American

A If the gas goes from one place to the other it is still available

Q Oh yes, it is there in the total? Then in the crude oil areas gas is going to be produced with the oil?

A Yes.

Q And as production goes on the pressure is going to decline?

A That is right.

Q At the same time under the British American plan and the work which is being done they are going to produce the gas cap wells in that area?

A Yes, but I believe the net production after you take the repressuring, is going to be very small or negligible for a year or two in the future.

(Go to page 629)

Q But there will be a reduction of pressure in the gas cap area.

A I am not certain as to that. I think certain plans envision having an increase in the gas being put into the reservoir. In other words the re-pressuring with greater production so that the gas cap could actually have of its own right an increase in pressure of a small amount.

Q So that the differential will be arrived at in the field in future, the future differential is going to get less and less and less until it reaches the point where they are together?

A Yes, I think it goes further than that. It will reach the point where the pressure will differ in the opposite direction.

Q Have you any idea where the point between 889 and 570 is arrived at, where it will be the same?

A I think very close according to the projections. I believe the 570 . in the gas cap will not change much over the coming years. It might go up slightly or it might go down, but it would not change very much and the oil pressure will gradually go down with production. So thatthe point where they will pass will be very close to the present gas cap pressure.

Q With the continued production of the crude oil area down to 250 pounds?

A That is the assumption I have made by the reserves, that is right.

Q Doctor, referring to gas production, I suppose you will agree with me the gas production from the crude oil area will be getting less and less?

A Yes.

Q And more of the total production from that area will come from the gas cap?

A Yes, and according to the various schedules set forth that is looking into the future before the gas cap net production becomes an appreciable portion of the gas.

Q Yes. That will be then they get together, that is six or seven or ten years hence and as they continue to produce they are going to go down in pressure together and there will be no migration under those circumstances.

A I do not believe it can be said that it was ever contemplated that they would go down together. I do not necessarily agree with that statement.

Q There will be very little differential.

A It might be comparable to the present differential that is in the opposite direction at the end.

Q The figure we are referring to now is approximately 300 pounds?

A Yes.

Q And if the gas cap pressure remains at 570 while the crude oil went down to 250 you will still only have a maximum differential of 300 pounds.

A That is right.

Q You will agree with me it is going to go down?

A It is going to go down and reverse in the opposite direction.

Q But between the two points it will never be more than 300 pounds?

A Yes, I think that is a fair statement.

Q Now Doctor I am not sure whether you were asked this or not. Have you any examples of where this reverse migration has occurred? I think you were asked that

by Mr. Steer.

A I do not think of any but it would be purely the result of circumstances and I do not know of any place where we have the same set of circumstances as that. I think it may be said that there are many examples of where they have had a change from a high pressure field to low pressure field, that is to say the reservoir pressures have changed with production in time and where it was a high pressure area it has become a low pressure area later on.

Q That was because of production?

A Yes.

Q That is not because of migration, it was because of production?

A Well it could be both.

Q Could be. Do you know of an actual case where it has been?

A Well if you would like me to give you an example of where migration has taken place.

Q Yes. In the first place, what type of formation was it?

A It was a loose formation.

Q Is it not so that there are two types of oil field? One limestone, such as we have in Turner Valley and the other is sand. That is a very rough division.

A Yes. There are different types of course.

Q And any example that is referring to anything but limestone has really no bearing on what we are considering here.

A Yes, it is a matter of permeability. The term permeability it does not matter whether it is sand or lime, fluid will

flow through the rock and that is referred to as permeability.

Q And then you would get into the question of porosity.

A Not for flow. It is only permeability. Porosity has nothing to do with it. It is only permeability that characterizes the sand or the limestone relative to its ability to conduct the fluid.

Q Now when Mr. Fenerty was questioning you, Doctor, he was referring to the re-pressuring of gas to be put in the gas cap, what have you to say about that re-pressured gas at the South end of Turner Valley moving into the crude oil area, can you estimate the amount of it? The percentages, or . . . . .

A I think it would be rather difficult to estimate the percentages. Of course it would depend on circumstances. One thing I repeat would have a bearing on it would be the percentage of gas phase that a man estimates as being present in the area through which this gas is migrating. As the percentage of gas phase increases the ease with which the gas will migrate will also increase through the whole oil area and whether you use the gas/oil ratio method or the material balance method or any other method, it will show an increase in the percentage of gas phase in the reservoir. It is now called an area and as that takes place the ease of migration also will increase with time even from now to the end of the reservoir.

Q The reason I asked you that, Dr. Katz, is we have evidence on that point before and at the foot of page 333 of the record Mr. Davis, dealing with the

matter of re-pressuring - well I think I should read you the whole answer and then you can tell me what you think of it.

"Now I think you want me to say what I believe the effect would be on oil production. If no gas be put back into the in-put wells pressure in the gas cap will decline more rapidly than it will decline if gas be stored therein. That will permit the formation pressure, what we think when we call bottom hole pressure, to decrease a little more rapidly down in the oil field than would be the case if the pressure in the gas cap zone were maintained and that is the reason in many oil fields today, many of them, the operators are pumping gas back into the gas cap as it is called to maintain a pressure throughout the reservoir not only in the gas cap but in the oil beneath it. The gas having to travel down. Take a field where oil lies directly beneath the gas. You put the gas in to the liquid. It exerts its pressure vertically downward and thereby tends to arrest the rate of decline in oil production. I think that would be a factor here. A factor of no consequence, but I cannot fail to admit that in theory there should be some effect and the amount of that effect I would not know how to measure. I think it would be modest but of some consequence. I want to say one more thing on that point. I cannot agree that gas put back in these wells in the gas cap area can ever be produced from

"the oil field wells generally. There might be a little of it get into the edge wells, that is all."

Will you go further than Mr. Davis?

A Do I understand your question to mean, for example, edge wells. If you look down the road five years hence after certain new crude wells have gone to gas, are you referring to the wells just beyond them or are you referring to these wells on the edge?

Q Just those wells themselves.

A Just those edge wells, then certainly I would go further than he has. But if you refer to wells that are taking production at a relatively low gas/oil ratio yet, I do not think the migration is going to be very large there. But I do believe migration will take place in the oil area, that was once an oil area and now has become gas cap in the oil area almost as great as it has in the gas cap itself.

Q Now that is a point I want you to come to. When you made up your estimates here you took one area in this field and said it was a gas cap?

A That is right.

Q In other words you boxed it and said there was so much in that area?

A That is right.

Q And you took the crude oil area?

A That is right.

Q And boxed it and said there was so much gas there?

A That is right.

Q And the fact that a well in the crude oil area has turned out to be a gas well does not take it out of the box.

A No, it should still stay in the box. That is right.

Q In the set-up of these wells there might be some wells that had produced some oil in the past but have now gone over to gas cap wells. They always produce at a high oil/gas ratio. Now those wells that have turned into gas wells, they are still in the crude oil area?

A Yes.

Q And the gas you estimate to be produced from that area includes the high gas/oil ratio gas wells?

A Yes, the area of course is specified as a group and the wells that are in the oil area remain there.

Q So that if you calculate the amount of gas reserves you have estimated in the gas cap will be produced from that box, which you call the gas cap . . . .

A Well it might migrate out, part of it, into the oil area, some of it, a percentage of it. It does not necessarily stay there. It can migrate.

Q The mere fact that the well turns to a high gas/oil ratio well does not make that a gas cap well.

A Well I should say this, the term gas cap is applied to that sort of an oil field with a high gas/oil ratio and produces substantial gas as well as oil. But when it is discovered as gas in that case it would be called an initial gas cap. That is many fields that are found as a complete oil reservoir with no gas phase at all they can develop a gas cap and we are confusing the two terms here. We have an initial gas cap and we have a gas cap in the oil area which develops by virtue

of production. We have not distinguished them too carefully in our conversations probably.

Q What I was intending to speak about was the initial gas cap, that is where the re-pressuring is going to be done under these plans as they now are.

A Yes.

Q If re-pressuring is done through the oil area or the secondary gas cap, that would be a question of creating an oil problem, attempting to increase the production of crude oil.

A Well there would be a matter of degree. You could store it in the gas cap area that has developed in the oil area or store it in the original gas cap area I believe, although you would be closer to the place in the oil field where the gas would, or where you would expect to have some benefit for production.

Q Dr. Katz, I was interested in one item you mentioned. What did you pay for your gas used in your domestic home at Ann Arbor, Michigan?

A I think this is right. I think the rate goes to 80 cents per thousand cubic feet at the rate at which I buy it.

Q 80 cents per thousand?

A Yes, it costs me approximately $150.00 per year to heat my home.

Q The initial use of gas in Turner Valley is to produce oil, that is in the crude oil areas.

A Yes. It is a gas drive field, yes.

Q And it has done some work when it has got the oil to the surface and made it available?

A Yes, it has assisted in bringing it to the well and

assisted in bringing it to the surface, that is right.

Q And what happens to that gas after it comes to the surface has no bearing on our production. It is wasted or burned or sold or disposed of in any manner and it does not affect what oil is going to be taken from out of those holes by the gas in the formation,

A No, the only way it could have any effect would be if it would be put back into the reservoir. Otherwise it can have no effect of course.

Q And the percentage of gas that is sold to the consumers, 41.8 per cent in one instance has no bearing on the oil income of operators of wells in Turner Valley. It has a bearing if they get money from the sale of the gas but has nothing to do with their oil production.

A I would not think so, no.

Q So that from the oil production standpoint, all that the operators are interested in is having the gas come out of the hole with the oil and bring the oil up.

A From the oil production standpoint, they are just interested in getting the oil out.

Q Is there any benefit to him in coming up to him and saying "close in your well, you cannot produce any gas" and he cannot get any oil out if he cannot produce gas?

A Yes, he cannot get any oil unless he produces gas.

Q So any conservation measure which has as its object the conservation of gas is bound to restrict oil production.

A Yes if that conservation measure has to do with

restricting gas coming from the wells, there is only a limit of control which the oil operator can put on the gas/oil ratio and if he wants oil he must produce gas.

Q And if the effect of a scheme of conservation is it causes a progressive, shall we say, accelerated increase in the gas/oil ratio it means he will receive less oil out of his well than if the gas/oil ratio was allowed to increase in its natural course in view of the circumstances of the particular hole.

A Well I think your question is two questions. First, if the gas/oil ratio rises by one operation over what it does by another in a gas drive reservoir without any auxiliary gas being put in the higher gas/oil ratio will give him a lower oil recovery. I think that is the answer to a portion of your question. I do not know if it is to the remainder.

(Go to page 639)

Q Now if that is the effect of the conservation scheme that is in force it is in reality a gas conservation scheme, not an oil conservation scheme ?

A Well if the gas conservation raises the gas-oil ratio it is by itself it would probably in a true gas reservoir such as you have. Conversely if it lowers the gas-oil ratio it would raise the oil production.

Q It would restrict the amount of oil production for an extensive length of time. I put this question to you and I would like to have your opinion on it too. That the amount of oil which any well can produce could be produced in the well in an unrestricted production. That is if natural gas-oil ratio increased according to the formation of the hole itself, the application of a scheme of conservation which would extend the life of the well for ten years, that would increase the ultimate production of the well ?

A Well I think it is the consensus of opinion that a controlled rate of production in a reservoir will give more oil recovery than an open flow unrestricted.

Q No I do not mean unrestricted. I mean the best gas-oil ratio operation ?

A Well I would say this that whenever a person can operate at a lower gas-oil ratio by one plan over a long period of time than he could by another in a gas drive reservoir, that procedure which permits a man to operate for a long period of time, that low gas-oil ratio should give him more oil recovery.

Q Any scheme that appears with that principle now which you mention is a detriment to the oil producer. If it prevents him operating at his lowest gas-oil ratio

over a period of time ?

A Yes if a man is forced to operate at a higher gas-oil ratio than he could operate at than he could expect without any introduction of gas into a gas drive reservoir he could normally expect to have a lower oil recovery.

Q You are familiar with the operation of the Brown plan, Dr. Katz ?

A Fairly well, yes.

Q Do you think dealing with individual wells - do you think the operation of the Brown plan would increase the ultimate production of oil from that well ?

A Well when I was here last summer I studied with the Committee that was considering this matter and although I did not make a thorough study, my observations were that I believe on the average the gas-oil ratio had gone down rather than up with the introduction of the plan and it would follow if that occurred over an extended period of time that you would get a greater oil recovery than you would otherwise.

Q That increased oil recovery if it was taken over, say a period of ten years, say the increase was 10%, you would have gotten 90% of your final output in three years and it took you ten years to get your 100%, would it be an economical operation ?

A No probably it would not.

Q The oil operator is really losing money on it by adopting the scheme ?

A Yes, the economics for a given well do not necessarily fit in for what is best for the whole field or the

country. That is certainly true.

Q So that if that was the effect on the crude oil wells, it would be an economic loss as far as the crude oil operators were concerned, to extend their life of operations for ten years ?

A I believe such statements you are making is assuming one individual is going to leave his well wide open. If you open the whole field up you are raising lots of questions, of course, that are far beyond our present observations and it is easy to assume that you are going to open one well up and you want to get the benefits of the other people keeping theirs in, but if you open them all up, that is comparing production back in the twenties or earlier times as with the present time, I believe the people who are working in the oil reservoir, engineering work, as I feel that is in that field, I believe they are of opinion that conservation in terms of controlled production over periods of time will give greater yields of oil in most cases than wide open production. You are probably familiar with the American Petroleum Institute that has a committee studying that for over thirty years and I have had the privilege of sitting in listening to that committee on their discussions for several years past.

Q I think Dr. Katz, Mr. Fenerty put this question to you, that dealing with the price of gas at the scrubber at the outlet of the scrubber if there was an increase in the price there to the ultimate consumer, that there would be a decrease in the total marketable gas and I

think you agreed with him ?

A That is a general law I believe that follows more or less depending upon circumstances. That is right.

Q That is the point, and the circumstances are, what are the alternative fuels that may be used ?

A Well I would say in the commercial installations that coal of course and fuel oil are the things that come up, but in the home you have them also, but I think there is a distinct difference between the margin of price rise that will change fuel from one kind to another in the industrial application of course than there is in the home.

Q Even in the industrial application it all depends upon the actual cost of the alternative fuel as compared to the cost of gas ?

A Yes and the cost of operation with the alternative fuel, yes.

Q And if there is seven, eight, nine, ten, leeway between the eight or less fuels and cost of gas, cost can increase that price up to that ceiling before there is a change over or decrease in consumption ?

A Yes if you are enjoying a margin to the gas to consumer over what the next competitive fuel would be why of course you would have a portion of that margin available, or all of it before you would change.

Q So that your answers to Mr. Fenerty are modified to the extent he did not bring that out ?

A I did not assume discontinuity. I assumed there might be one consumer on a narrow margin and another on the next narrow margin. I did not assume in the

statement in detail that there was a discontinuity before you reached any of them .

Q I think that is all then.

CROSS-EXAMINED BY MR. CHAMBERS:

Q Dr. Katz the first questions I propose to address to you are most elementary or academic and I know you won't think I am questioning your knowledge. I am being frank with the Commission and at the same time, all of us, especially laymen, use certain terms in connection with these matters and I feel certain I did not understand and I would like to get on the record some of these elementary terms and what they mean. With that object in mind I am going to ask you questions that might seem to you of the kindergarten variety. We have heard a lot of the word porosity. Can you tell us in laymen's language what that is ?

A Porosity is the space within a rock. If you take it out and clean out all the fluid that is in it it is the space in that rock that would be filled with air for example. It is the space in the rock that is not composed of sand or silica itself and one way of measuring it would explain it as well as any probably, is to clean the rock well, remove all the fluid present excepting air, evacuate the rock and filling it with a fluid of known density. You weigh it before you put it in and afterwards, and knowing the density of the fluid you have filled the pore space with you can obtain the volume and in measuring the volume of the rock you get the total of the porosity.

Q And in Turner Valley I understand it is a limestone field in the opinion of engineers and geologists the formation is porous and those pore spaces are what contain the oil and gas ?

A Yes. I think there are two kinds of space that is porous and there may be a given rock arrive at a given porosity and be uniform and there may be non-uniformity where the pores are relatively large and there may be both kinds in Turner Valley.

Q Along with that we hear the term permeability. As a matter of fact it was discussed here a few minutes ago. Will you try to explain that term to us ?

A Permeability is a general term used for indicating the rate which fluid will flow through a given substance solid and I have measured many permeabilities and the procedure is to clean the core again, remove all fluids excepting air, place the core in a holder, pass air through the core and measure the pressure differential across the core, take the dimensions of the core and the rate of flow of air and you arrive at a permeability and the standard term is a Darcy and we speak of the permeability of cores in terms of Darcy, which means that the higher the permeability the greater would be the flow over a given pressure differential or for a given flow the smaller pressure differential that would be required.

Q In other words permeability has some relation to the connecting space between these pores you are talking about. Is that true ?

A That is right.

Q Now one of the other terms we hear is that gas-oil ratio. Just what is that in ordinary laymen's language ?

A When the oil comes to the top of the well with its component gas it is normally separated in the separator. The gas is measured in standard cubic feet. We refer to gas as so many thousand cubic feet and they are measured at 14,4 and at 60 degrees F. and the oil is normally measured in barrels and we represent a cubic foot of gas under standard conditions per barrel of liquid has been produced as gas-oil ratio.

Q Well the term then as I take it from what you said is this, it is the proportion of gas and oil in the volume of production that comes out ?

A Yes but measured at different conditions.

Q But the term gas-oil ratio has reference to the quantities of those two elements in the -

A The ratio,-the quantities of the fluid as they are measured, yes.

Q Well then we have heard a lot about and I am sure we are going to hear more, the bottom hole pressure. What is the bottom hole pressure ?

A Well of course bottom hole pressure is the pressure at the bottom of the hole, at the bottom of the well. It is the pressure exerted by the fluid at a given depth. We usually have bottom hole pressure as of a certain depth because the place where you measure it makes a difference.

Q And that is the pressure exerted from the reservoir to the bottom of the hole ?

A It is the pressure exerted by the fluids at that particular point.

Q What do we mean by shut in bottom hole pressure ?

A That means the well is not flowing when you are measuring it.

Q And what is this term, rock pressure. Is that the same as bottom hole pressure ?

A No rock pressure is a term that is used primarily in the earlier days and still used some. I think primarily rock pressure is used to represent the well head pressure on gas wells but I never use the term myself as a general term because it has the inference in it that it is in the reservoir when I think the measurement is normally usually made at the top of the hole.

Q One of the reasons I mentioned that I think it went to the United States Appeal Court where they spoke of leases and the question of rock pressure was of great importance. That is my object in trying to clear that term up for the record.

MR. BLANCHARD: Excuse me, did I get that rock pressure was bottom hole pressure ?

A The term I believe is used and refers to the well head pressure of gas wells. I believe that is the term. That is the most likely use of it although I think it is misunderstood on many occasions.

Q MR. CHAMBERS: Now in talking of this question of bottom hole pressure, there is the term weighted bottom hole pressure and there is the other term you spoke of yesterday, arithmetic average bottom. You might explain the difference in those two terms.

A In order to average pressure we are normally thinking of a group of wells, and if you had a dozen wells in the area and were reaching the pressure in that area by the average of these wells, you would take the individual pressures at the bottom of the hole and average them by some procedure. One procedure is to simply take the twelve pressures, add them up and divide them up by twelve. That would be the arithmetic average. Another procedure would be to multiply those by some weighting factor, which assigns more weight to one well than another, and then adding up the total quantity, and then dividing by the weighting factor and you would have the average pressure by the weight.

Q MR. CHAmbers: Now Doctor, this description was given to me of weighted bottom hole pressures, and for the record I would like to say, have it show to have the weighted average bottom hole pressure, is calculated the bottom hole pressure of the edge well, then you draw a contour map of equal pressure, then you take the average pressure on the basis of area and then divide by the total area, is that the way that you would get at it?

A That is one way of getting a weighted pressure. That is right.

Q That is one example?

A That is one example.

Q Now I have run into the term of liquid loading. What does that mean?

A Well as I understand the term, I think I know what you are referring to, and that is if you have a well that is producing gas,for example, and the liquid accumulates in

thebottom of the well and consumes a portion of the pressure between the bottom of the well and the top of the well as a liquid load, it leaves very little pressure differential to cause the well to flow, and it is quite possible, and I have tested many wells where they had 1400 pounds bottom hole pressure, and you could stand there and the well head was open, because all of that pressure is represented by the column of liquid, and the loading of wells is building up a column of liquid and the effect is to consume the pressure differential from the bottom of the well to the top of the well.

Q Well in ordinary layman's language, who does not understand the technical terms, it would be this, that the well becomes loaded with liquid that prevents the pressure at the bottom from bringing up the natural production at the foot of the hole.

A Yes, that is it. It decreases the pressure that is available to produce the gas, if you had the gas well loaded.

Q Now I have heard the term "water-drive" talked about in connection with this Turner Valley field. What does that signify?

A Water-drive is the intrusion of water normally from the lower edge to displace the hydrocarbon fluid present, presumably in the usual state of gas there is a pressure behind the water so that if the pressure in the reservoir is decreased, it causes the water to migrate into the reservoir and displace the hydrocarbon fluid.

Q Now is that the same as water expansion, I have heard that term used here?

A The pressure behind the water may be simply expansion of a

given quantity of water and that expansion will cause the water to come in slightly at a lower rate.

Q Then the water-drive, I take it, there is some other force in behind the water that is driving it in, is that right?

A No. I think the term "water-drive" refers to the intrusion of water into the oil reservoir, and the term "water-expansion", I believe is a descriptive term of the mechanism of a particular water drive.

Q Now to what extent and where are these two features "water-drive" and "water-expansion" present in Turner Valley? Have you given any study to that?

A Well the observations that I have made is with the production of water from the edge wells, and there are only a few wells that have produced water, and there has not been a gradual migration to a water front, because the normal water-drive, when we speak of the reservoir in a water-drive, the extent to which it has taken place, there is substantially no water-drive.

Q It is not an important factor?

A No sir, it is not an important factor.

Q And when you speak of edge wells, you are referring to which wells?

A Built structurally low.

Q And it is not an appreciable factor in computing the reserves in Turner Valley?

A I do not believe that it is.

Q Now then, I understand that there is more than one method to be adopted by engineers or geologists, as the case may be, at arriving at estimates of production, of probable production of the field. You tell us that you use the

material balance method. I understand there are at least two others. One is known as the porosity method and the other as the production decline curve method?

A That is right.

Q Can you give us just in a few words what the porosity method is? What it means?

A The porosity method applies where you know the acres of the field and you know the thickness of the horizon, assuming it is a uniform horizon. You measure the porosity of the sand from the cores, you get the total cubic feet, multiply the porosity and get the total space in the reservoir, and knowing that you can compute the initual oil present and assume so much present.

Q And the production decline curve method?

A That is the method of plotting rate of production versus time. You plot it on various kinds of paper, log paper where you plot log versus sraight co-ordinates on other kinds of paper, and if you plot it on that and you get a straight line it is customary to draw that curve to the future as a straight line and assuming that is the rate of production. That is a common method, common in our territory up to the time of proration, when the oil wells were producing in open flow condition, excepting for clean-outs of the well or some possible mechanism of producing the oil to the surface. It was reasonably reliable.

Q Now those two were the two older methods.

A Yes, prior to 1935.

Q The material balance method that you spoke about, I think you have told us that you had considerable to do with working it out. It is one of the newer methods, comparatively newer.

A It was developed primarily because of proration. When proration started in the Midcontinent area, they had no proration and it would go up and down depending on the Commission orders, so that it was necessary to arrive at the oil by some other procedure and it was with that in mind that the material balance method was developed.

Q Then these three methods, the porosity method, the production decline curve method and the material balance method, are those the three more or less standard methods that are used or are there others?

A With variations of them I would say they are the three.

Q And you have chosen the material balance method, and I suppose it is fair to say that you have chosen it because you figure it was the best?

A Yes.

Q In your judgment?

A Well yes, it is the best. And the other method of production decline, the production decline method may require more specific information which would not be available to me and may require some judgment, which would not be as available to me as a person working in the field.

Q As I understand it, then, if you are going to use either one of the two older methods, the person who is making the estimate needs to get considerable time in checking information and being in touch with the area?

A Yes! The porosity method requires a detailed knowledge of the geology and the production in the whole field, and the other a detailed study of the edge wells or the area with the decline curve.

Q Now turning to your material balance method, and here again I think you will admit to those of us who are not versed in

matters of petroleum engineering, it is somewhat difficult to understand at first, but I would like to get by reason of a series of questions, by means of a series of questions, more or less of an outline that would be intelligible as to the w ys and the wherefores of some of these calculations that you make. Now, as I understand it, your method involves first of all an assumption that there is a definite constant reservoir.

A Constant volume reservoir.

Q And that reservoir is the producing formation that is full of these pores or spaces?

A It is connected by the wells drilled.

Q Yes. Connected by the wells that are drilled?

A Yes, it is the porous spaces in the reservoir that is connected to the wells that are drilled.

Q Do I understand by that that you regard the Turner Valley area as being different containers or different reservoirs?

A I have a group of wells for the purposes of a calculation, and I have assumed that they were in a container, but although I do not necessarily mean that they were themselves in that container, I had to make an assumption in order to group those wells, and I assume that the reservoir space attached to those wells was a constant volume.

Q And that is the reason that you took the different areas when you came to make up your report, because you considered they are then more or less segregated?

A No, it was a matter of wanting to know the answer for a given area without taking the average factors of the whole reservoir, the conditions of the area.

Q In other words, you think it was more accurate to take the

whole area?

A Certainly it was more accurate to take the information for the area itself.

Q And if you have more accurate information for each area, your over-all answer naturally would be apt to be closer?

A I would not think it would have much difference, the over-all answer, if you would use the whole reservoir as one item, as compared with some of the others, but it does give more detailed information for each given area than you can get from the over-all.

Q In any event you have the reservoir, which is the container, Dr. Katz, and in that reservoir there is crude oil or oil, we will say, with gas in solution, or in other words the gas is dissolved and permeates the oil in its virgin state in that container?

A I don't like the term permeate. It is like a solution to look at it under pressure in a glass, and if it is put in a window it will look like any other solution.

Q That is the situation before any production is taken out? Before there is a well? And then I understand that your next premise is that the mixture of crude oil and gas will behave in the same way in the reservoir as it would behave in the laboratory under similar conditions of temperature and pressure?

A That is right.

Q That is right, Dr. Katz?

A Yes.

Q But there must be similar conditions, or we must get to pretty close similar conditions of temperature and pressure?

A Yes, that is right.

Q As I understand it, the pressure is important because the

greater the pressure in the reservoir, the container, the greater the amount of gas dissolved in each barrel of oil in that reservoir, is that right?

A Yes. You are thinking of the time that the pressure in the reservoir is decreasing. Of course it also applies.

Q I am assuming first of all before there has been a well drilled, the higher the natural pressure down in that reservoir the more gas you have in each barrel of oil down there.

A We have assumed that the solubility of the gas depends upon the initial pressure under which it was discovered.

Q So that therefore that is one of the reasons that pressure is important down there, Dr. Katz?

A Yes.

Q Now then, the question of temperature. As I understand it, the temperature is also an important factor because the higher the temperature of the mixture in the reservoir the less gas there is per barrel in that reservoir?

A That is right.

Q Then one of the first things to be ascertained or estimated is the original reservoir pressure?

A That is right,

Q And there are various ways that we go at it, and one of the ways for us to arrive at that information is to take the bottom hole pressure of a well or wells in virgin territory where little or no production has been taken, is that right?

A That is right,

Q And with that well or those wells, the pressures taken from them are assumed to be or taken to be representative of those initial reservoir pressure?

A Yes. Not necessarily all the wells, depending upon the production around them. But the best you can do is to find

the well that is earliest in the field. Of course the ideal situation in the field is to measure the first well that comes in.

Q Yes?

A In the absence of that information you have to take the first measurements, take into account the production that may have taken place adjacent to it and then consider the information as it applies to the reservoir as a whole.

(Go to page 656).

Q And as I understand it in the case of Turner Valley, that information with respect to the initial reservoir pressure was based on the pressures which were taken at the Home-Millerville 2 Well in December 1938?

A That is one of the wells used, yes.

Q And there were other representative wells too?

A Yes.

Q But the Home-Millerville 2 was one of the important ones, was it not?

A Yes.

Q Now why was the Home-Millerville 2 chosen?

A Because it was a long ways from production, at the time it was drilled, and the pressure measurement was taken shortly after drilling in the well.

Q That was in what we call the north end?

A The north end, yes.

Q Now I suppose there should be another well taken or a well taken down in the south end?

A The other well which was taken particularly as being significant, was the Merland #1.

Q Why was that taken?

A It was taken, on looking over the pressures and the times when they were taken relative to adjacent drilling and adjacent production, the well appeared to be one of the earliest from the standpoint of pressure reduction around it.

Q And then there would be others taken in the central area, one or more taken in the central area?

A Well checks would be made, if you would like me to, I would like to explain how I arrived at it.

Q Yes, I think that would be interesting?

A It is included in the statement in the supplementary report

but it is not really explained. Given this Merland #1 Well as a Top-hole-pressure, casing head pressure, and computing the gas gradient, the gradient of increase in pressure as you go down the well and into the reservoir, I plotted the curve down too, I think it is minus about twenty-two hundred feet, at which point approximately in the reservoir was believed to be the contact between the oil and the gas. At that point then we should change the gradient from that of a gas gradient to that of an oil gradient, so I set the curve at that point and drew one from there through to the Home-Millerville 2, and that curve should give the gradient of thirty-three pounds per hundred feet, which is in accord with the gradient in an oil well or in an oil reservoir and that curve has been compared with other data and appears to be a fairely reliable estimate of the original pressures in the reservoir.

Q Then we are at the point where we have the original reservoir pressure and as I understand it the next step is to ascertain the amount of oil or gas production which has actually taken place, which has actually been taken from the reservoir as at a specified date, the date on which you were going to make your calculation?

A That is right.

Q That is the next step?

A That is right.

Q And having that information, the next step is to ascertain the actual reservoir pressure with that production having been withdrawn?

A That is right.

Q And that the pressures of the reservoir taken at that stage should also be representative of the entire area?

A That is right.

Q So that when you are taking the original reservoir pressure, you want to get a representation of the whole reservoir and when you take the certain amount of production out, your object is to try and get that tested, so that it would be as representative as possible of the entire area that you are calculating on, that is right as I understand it, Dr. Katz?

A That is right.

Q Now then our information is that in order to obtain that data, that is the present bottom hole pressure, the ideal way is to select representative wells and shut them in for a sufficient period of time for them to obtain or build-up to a true reservoir pressure, is that right?

A That is correct.

Q Now how long do you consider it necessary to shut a well in in Turner Valley to obtain this data?

A That all depends upon the well. It may vary from, I suppose a day or two to possibly a month.

Q Well now why is the difference?

A Because of the low permeability. The low permeability of the limestone around the well, has resulted in a condition of a lower pressure adjacent to the well due to its prior production, than would be respresentative of the reservoir area.

Q I see. As I understand it, the lower the permeability the longer the period the well should be shut in?

A Well in general, yes, for a given rate of production. Of course it would also follow for a higher rate of production, a longer time of production for a given well.

Q We now have the following factors then, first of all you have the original bottom-hole-pressure; then you have the amount of the oil and gas which has actually been produced; then you have ascertained the reservoir pressure after that production has been taken out, at that previous time?

A Yes.

Q And then the next thing you must know and want to find out is what are the physical properties of that crude oil gas mixture which comes from the ground, from the reservoir?

A Yes.

Q That is right, is that right?

A That is right.

Q Now in the latter category, you seek to ascertain certain things about the physical properties or characteristics of the mixture, as I am calling it and the first thing you try to ascertain is the solubility of the gas in the crude oil, is that right?

A That is right.

Q And the next factor which you try to ascertain or you do ascertain in the laboratory is the shrinkage factor.

A They are measured together, yes.

Q And this shrinkage factor is obtained in the laboratory by allowing the solution of oil and gas at a known temperature and pressure to vaporize at an ordinary atmospheric temperature and pressure, is that correct?

A No. The shrinkage, no, the way we represent the shrinkage curve, the shrinkage can be obtained in that matter but that is not the kind of shrinkage

curve which we have. The kind which we use in this Material Balance, is a measurement of the volume of the liquid before any gas comes out and then the subsequent measure of the volume of the liquid at the lower pressure, and then those quantities are recorded.

Q Then as I understand it the third thing which you seek to find in the laboratory is the deviation of the gas taken from this mixture, from the ideal gas.

A That is right.

Q Just what does that mean?

A What does that mean?

Q Yes, what is the ideal gas?

A The ideal gas law says this, double the pressure you will double the volume of gas, it also says if you increase the temperature by 50 per cent, the temperature scale, that you will increase the volume by 50 per cent and it is the generally accepted law for pressures up to 50, 100 pounds per square inch. It has been found over a period of years of course that gases do not follow this ideal law exactly, but a correction must be applied to that law.

Q And that is one of the things, the third one which you need?

A Yes.

Q And which you ascertain in the laboratory?

A Yes.

Q Now then, as I understand it, those factors, that is the original reservoir pressure as I call it, the oil and gas actually produced, the reservoir pressure after that known production has been taken and the

physical properties of the crude oil and gas mixtures indicate certain things and one of them is, first of all, the actual crude oil produced is one portion of the original crude in the reservoir, that is self-evident.

A That is self-evident.

Q And second, the gas actually produced in excess of the ratio which is in the original mixture, accounts for a further portion of crude oil originally in the mixture, is that right?

A That is right.

Q That is a crude way of putting it but that is substantially correct is it not?

A Yes, yes.

Q And it also indicates, to that extent the original reservoir conditions are now altered of course.

A Yes, the fluids are no longer in the same state that they were initially.

Q And the next thing is that a space has been left in the reservoir when the crude and the gas were produced and that this space is now occupied by gas which has vaporized from the original liquid.

A That is right.

Q And it also would indicate that the volume in that space can be calculated as containing a definite quantity of gas, that would vaporize or be separated from the crude at a definite number of cubic feet per barrel.

A Yes.

Q And it also tells you that the cubic feet of gas in that space, that is the space which has been vacated by the production, divided by the gas realized per

barrel of oil, is the number of barrels of crude that must be present to maintain the reservoir pressure as at the date that the computation is being made.

A That is right.

Q So now then, you have obtained by following those various steps, the total amount of crude oil initially present in the reservoir, you had the actual production and you had the amount of oil necessary to produce the excess gas, and the amount of oil necessary to produce the gas that was necessary to maintain the bottom hole pressure as at the date of your calculations.

A Yes.

Q And then the gas, having all that, the gas present is then calculated from its solubility with the crude oil, is that right?

A Well the gas present in the reservoir.

Q And the crude oil present in the reservoir.

A The crude oil is computed from the quantity of gas in this space, knowing the change in solubility and the change in the initial conditions from the beginning down to a given date.

Q Now is that more or less a general outline of the procedure you followed in the use of this Material Balance method?

A Yes, it is.

Q And I think you have already told one of my learned friends that in making these calculations occasions arise where you must exercise your judgment in the light of your experience and engineering knowledge and in making your calculations here and your estimates,

you have erred, if at all, on the conservative side.

A That is right.

Q What do you consider the oil-water contact in the Valley, have you given any consideration to that?

A I have not determined it exactly but you would call it somewhere in the order of -4000 but I have not checked it particularly. I think it is quoted in one of these reports.

Q My information is that it is around -4300, is that roughly correct?

A Yes.

Q Now what do we mean by the oil-water contact?

A The oil-water contact presumably is the point, if you were looking at a layer of water, oil and gas, it is the level at which the oil and water meet and in most fields they find that it is about the same place although there are some fields where their oil-water contact of course is, does vary in different places with the field.

Q When we refer to the water, we refer to . . . . .

A The edge water.

Q The water which is naturally in the formation.

A Yes.

Q And there is oil in the formation and in certain fields you will look for it and expect it by reason of the information which you have, at certain depths or levels.

A That is right. You have your observation on the discovery of water in the oil and normally that would tell you whether you were below, - at the

point where you found the water you are below the oil-water contact.

Q What is the depth of the contour for the oil and gas contact, have you given any consideration to that?

A The data which I have used is -2200. That value only came into effect in the determination of the initial reservoir pressure. I would like to state that that -2200 does not mean the top of the limestone, which fact might be confusing in certain cases.

Q You have already told us that the production in the Valley is from what we call the "limestone horizon".

A Yes.

Q Now I have heard it said more than once here that Turner Valley is what is called a "spotty field", what do you mean by that?

A Well it would mean to drill a well . . . . .

Q First, do you agree with that, that it is a spotty field?

A Yes, it is.

Q What do you mean by that?

A Well you mean if you drill a well in a given place, although its location is such in the general structure that it ought to be a good oil well but it may be a poor oil well and you drill in another place and you decide because of the data available that it should be a poor well, a poor oil well but it turns out to be a better oil well. It really has reference to the permeability of the rock at the well border where it pierces the particular producing horizon. Some of them are of low permeability

and some of them are high. It is from the fact that their ability to produce fluid is different.

Q Yes, the field as a whole has a low permeability but on the other hand certain areas are even below the average.

A Yes, and others are above the average, that is right.

Q Now as I understand it there is an area known as the "central section", where there is a very low permeability.

A Yes, it is the South, just South of Sheep River where the oil wells are being drilled, and they are the poorest oil wells as I understand it for virgin oil wells in the field.

Q What effect does that low permeability have on production?

A It means the production is lower.

Q And you will get, you can expect less ultimate production from a well in an area of low permeability?

A Yes; if the same quqntity of fluid were there you would get it over a longer period of time too.

(Go to page 666)

Q Now turning to the gas cap and at Table 1, page 8, Doctor, of Exhibit 34 which is your July report, pages 8 and 9. The Table is said to be an estimate of original reserves of gas in Turner Valley gas cap. Would you please indicate to me the area or acreage that you are including in the Turner Valley gas cap for the purposes of that table?

A The area is clearly defined on a map that should accompany the report. If you want a verbal description I guess it can be given. I have a map but there are only the wells shown on it.

Q You did not arrive at any acreage estimate?

A I did not particularly compute the acreage, I do not recall.

Q One of the reasons I am asking is we have had various hearings at various times and you hear divers figures as to the areas and I would like to get on the record the acreage that you are taking into that area. I am not suggesting that you sit down and compute that yourself but I wish you would have somebody do that so that we can get it on the record what acreage you are considering in that table. Would it be possible to have that done?

A I think I have it here if you will let me look it up in some of my work notes.

Q I will be quite content if we have the answer to that tomorrow.

A I will have it in just one moment if you will give me time.

Q Oh all right.

A The acres that are the same for the three assigned acres

in weighting the pressure for the three years of the supplementary report total 5,571 acres.

Q That is the total gas cap area included in your supplemental report.

A That is the total acres that were assigned that I used in weighting the average pressure.

Q Now then on page 5 of Exhibit 34, your report of July, 1944, Item 2, you there use for the purposes of your computations the average arithmetic casing head pressure of gas cap wells as taken from the annual survey of some government board and I infer the Conservation Board in June of each year, is that right?

A That is right.

Q And you plotted those values against time to get the values for the date indicated in Table 1, item 2 on page 8, Exhibit 34, is that right?

A That is right. Down to . . . . Well, yes, that is right.

Q Then on page 5 again, turning to item 3 of that same exhibit you then calculated the density of the gas column by adding items 2 and 3 together and you calculated the average reservoir pressure as shown by item 4 on Table 1 on page 8, is that right?

A Yes.

Q And applied that method for calculating the average reserve pressure as of December 31st of each of the years 1935, 1936, 1938, 1939, 1940 and 1941.

A That is right.

Q And in calculating the average reservoir pressures as of December 31st of each of the years 1942 and 1943,

however, you used the arithmetic average of the reservoir pressures as computed for the individual wells as of July 1st in each year.

A For 1942 and 1943 I had available the bottom hole pressures directly so that they were applied rather than the average well head pressures and converting those from well head pressure to bottom hole pressure. Now I think I said something that was not quite correct a minute ago in answering your question that I have plotted the bottom hole pressures in functioning with cumulative gas production and if I recall correctly I answered yes to your statement as you said I employed well head pressures. I applied bottom hole pressures against the accumulated well pressure and not the well head.

Q And you used the bottom hole pressures for 1942 and 1943, why?

A Because they were available. They had already been computed as the bottom hole pressures in the tabulation which I was taking out and in the earlier years they were not available as bottom hole pressures. I would have had to make some hundreds of conversions.

Q A question of time?

A Yes, just a question of time.

Q If you turn to Exhibit 35 which is your supplemental report and on page 2. . . . .

THE CHAIRMAN: Mr. Chambers, are you starting a phase now that you can finish in six minutes?

MR. CHAMBERS: I am really getting into the meat of this report now.

THE CHAIRMAN: You are starting a new phase?

MR. CHAMBERS: Yes.

THE CHAIRMAN: I was thinking this might be a convenient time to adjourn.

MR. CHAMBERS: Yes, I think it would.

THE CHAIRMAN: We will adjourn until 10 o'clock tomorrow morning.

(At this stage the hearing was adjourned until 10 A.M. 14th March, 1945.)

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